REMARKS

This Amendment is submitted in response to the outstanding Final Office Action, dated January 26, 2005, and is accompanied by a Request for Continued Examination. Claims 1 and 6 are proposed for amendment herein. Claims 1-11 are presently pending in the above-identified application.

Rejection of Claims under 35 USC § 112 and Objection to Specification

The Office Action rejected claims 1-11 under 35 USC § 112, first paragraph, as failing to comply with the written description requirement, in particular, with respect to the phase "independent of a flow state" introduced by Applicants in the independent claims set forth in the prior Amendment, dated October 29, 2004. The Office Action further objected to the specification for failing to provide proper antecedent basis for such amended claim language.

While Applicants respectfully disagree with the rejection of the claims under 35 USC § 112, first paragraph and the objection to the specification, Applicants, in order to expedite the current prosecution thereof, have removed the subject phrase from the pending amended claims herein thereby rendering such rejection and objection moot.

For completeness, it will noted that the subject phrase (i.e., "independent of a flow state") to which the rejection/objection is directed and the current amendments to the claims herein are both aimed, in part, at more particularly claiming the "friction control" aspect of Applicants' invention. Support for the limitations added in accordance with the amended claims herein is provided as set forth hereinbelow. Further, Applicants respectfully again submit (as set forth in the prior Amendment) that the previously cited Meng reference (i.e., U.S. Patent No. 5,934,622) is primarily directed at a technique for suppression of turbulent drag and affecting a turbulent envelope (see, e.g., column 5, lines 36-38) and is not particularly relevant to the present invention. That is, in contrast to Meng, as discussed in the prior Amendment, Applicants' claimed invention (in accordance with amended claims herein) is directed to "skin" drag reduction without concern with (or influence of) turbulent drag or turbulent envelope. Applicants' drag reduction is achieved through the utilization of nanostructures or microstructures

disposed on a surface in a way such that the contact between the surface and a fluid is reduced and the claimed friction control between the surface and the fluid is controlled as a function of a surface energy of the nanostructures or microstructures and wherein the friction control is a function of a variable degree of contact between the surface and the fluid resulting from an electrically-induced penetration of at least a portion of said fluid through the nanostructures or microstructures disposed on said surface. None of these aspects of the claimed invention are taught or suggested by Meng (or any of the prior art of record set forth hereinbelow) as further set forth hereinbelow.

In view of the foregoing, Applicants respectfully request that the objection to the specification and the rejection of claims 1-11 under 35 USC § 112, first paragraph, be withdrawn.

Rejection of Claims 1 and 6 under 35 USC § 102(b)

The Office Action rejected originally filed claims 1 and 6 under 35 USC § 102(b) as being anticipated by Japanese Publication No. 2001-114185 of U. Masahiro et al. (hereinafter the "JP ('185) reference"). Applicants have amended the claims herein to more particularly claim the various aspects of the invention, and respectfully submit that each of the currently pending claims is patentably distinct from the JP ('185) reference for at least the reasons set forth hereinbelow. In addition to the discussion below, the Office Action on page 4 further supports that the frictional resistance technique in accordance with the JP ('185) reference does not teach or suggest Applicants' claimed invention, as set forth in the amended claims herein, and that the limitation added to the amended independent claims is at least sufficient to overcome the subject §102(b) rejection.

The various aspects of the present invention are directed to a method and apparatus wherein nanostructures or microstructures are disposed on a surface of a body (such as a submersible vehicle) that is adapted to move through a fluid, such as water. The nanostructures or microstructures are disposed on the surface in a way such that the contact between the surface and the fluid is reduced and, correspondingly, the friction between the surface and the fluid is reduced (see, e.g., Applicants' Specification, page 2, lines 1-9).

Importantly, the friction control (i.e., "skin" drag reduction) between the surface and the fluid is controlled (1) as a function of a surface energy of the nanostructures or microstructures (see, e.g., Applicants' Specification page 2, lines 13-15; page 7, lines 1-27; page 8, line 15 through page 9, line 27; and page 10, line through page 11, line 17); and (2) wherein the friction control is a function of a variable degree of contact between the surface and the fluid resulting from an electrically-induced penetration of at least a portion of the fluid through the nanostructures or microstructures disposed on the surface (see, e.g., Applicants' Specification page 2, lines 17-22; page 6, line 30 through page 9, line 27; and page 11, line 18 through page 13, line 11).

The aforementioned friction control, in accordance with the principles of the invention is achieved, in large measure, as a function of the reduction in the liquid-solid interface achieved by the introduction of Applicants' nanostructures (or microstructures) on the surface of the body moving through the fluid. That is, applying the principles of Applicants' claimed invention allows for a reduction in the contact area of a body's surface which actually comes in contact with the fluid in which such body is immersed (see, e.g., Applicants' Specification, page 2, lines 13-15; page 5, lines 31 through page 6, line 5; page 6, lines 23-26; and Figures 9A and 9B). Thus, Applicants' claimed invention realizes friction control without regard to the fluid flow (i.e., turbulent or laminar flow) in which the body is immersed (i.e., "independent of a flow state of the fluid"), and without requiring a direct change or affect on such fluid flow. The nanostructured/microstructured surfaces of the claimed invention will apply equally in either turbulent or laminar flow situations and deliver the advantageous friction control of the claimed invention.

Further, the claimed friction control is a function of a variable degree of contact between the surface and which results from the nanostructures or microstructures being disposed, in accordance with the principles of the invention, on the body's surface (e.g., a submersible object). This is achieved by the Applicants' realization that it would be desirable to use electrowetting principles coupled with nanostructured (or microstructured) surfaces to vary the characteristics of the movement of underwater vehicles (see, e.g., Applicants' Specification, page 6, line 30 through page 7, line 1). That is, in accordance with Applicants' invention, as claimed in the amended claims herein, fluid is caused to at least partially penetrate the nanostructures or microstructures

on the surface of the body in order to selectively create greater friction in a desired location of the surface. Advantageously, such selective penetration of the fluid resulting from the electrically-induced penetration of the fluid through the nanostructures or microstructures, in accordance with the invention, may be used to create drag that alters the direction or speed of travel of the body through the fluid (see, e.g., Applicants' Specification, page 2, lines 17-22; and page 12, line 27 through page 13, line 11).

Applicants have amended the pending independent claims to more particularly claim the above-described aspects of the invention. For example, amended independent claims 1 recites:

> "An apparatus comprising:
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> a surface on a body, said body adapted to move through a fluid; and
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> a plurality of nanostructures or microstructures, each nanostructure of said plurality of nanostructures having at least one dimension of less than one micrometer, and each microstructure of said plurality of microstructures having at least one dimension which is less than one millimeter, disposed in a pattern on said surface in a way such that friction between said surface and said fluid is controlled as a function of a surface energy of said nanostructures or microstructures and wherein said friction control is a function of a variable degree of contact between said surface and said fluid resulting from an electrically-induced penetration of at least a portion of said fluid through said nanostructures or microstructures disposed on said surface." (Emphasis added by Applicants)

Each of the currently pending independent claims has been amended in a similar fashion as the above-referenced amended claim 1 to contain similar limitations.

Applicants understand the JP ('185) reference to disclose a method for reducing resistance of a ship's hull through the use of very fine grooves formed along the direction of seawater in the surface of a ship's outside plating wherein the grooved surface is also treated with an anti-fouling treatment to increase the resistance of the hull from marine organism adhesion (see, e.g., the JP ('185) reference, Abstract; and page 1, paragraphs [0001] through [0011]). Pursuant to the discussion above, the JP ('185) reference does not teach or suggest the Applicants' claimed invention, as set forth in the amended claims

herein, where drag reduction is achieved through the utilization of nanostructures or microstructures disposed on a surface in a way such that the contact between the surface and a fluid is reduced and the claimed friction control between the surface and the fluid is controlled as a function of a surface energy of the nanostructures or microstructures and wherein the friction control is a function of a variable degree of contact between the surface and the fluid resulting from an electrically-induced penetration of at least a portion of said fluid through the nanostructures or microstructures.

Further, with respect to Applicants' pending dependent claims 5 and 11, these claims are directed to a further aspect of the invention wherein the fluid is caused to penetrate the pattern of nanostructures or microstructures at a select location on the surface such that the penetration of the fluid at the select location alters a direction or a speed of the vehicle in the fluid (see, e.g., Applicants' Specification, page 2, lines 20-22; and page 12, line 27 through page 13, line 8). Nothing in the JP ('185) reference teaches or suggest this further aspect of Applicants' claimed invention.

Rejection of Claims 1, 2, 6, 7, 10 and 11 under 35 USC § 103(a)

The Office Action rejected claims 1, 2, 6, 7, 10 and 11 under 35 USC § 103(a) as being unpatentable over German Patent No. DE 19704207A1 (hereinafter the "DE ('207) reference"; Applicants have submitted, concurrent with this Amendment, an English translation of such German reference; also all citations herein by Applicants regarding this German reference are citations to the English translation thereof) in view of Japanese Publication No. 08-128413 of S. Fumio et al. (hereinafter the "JP ('413) reference"). Applicants respectfully disagree and submit that the amended claims herein are patentable over the DE ('207) reference and the JP ('413) reference taken alone or in any combination.

With respect to the DE ('207) reference, Applicants wish to first highlight that the friction reduction technique described therein is primarily directed at a technique for suppression of turbulent drag and affecting a turbulent envelope. That is, turbulent drag is reduced by changing/affecting the overall turbulent envelope in which the body is immersed. See, for example, bottom of page 3 through top of page 4 which states "...This is based on the fact that vortices do not form on hair ends, which statically repel

the water from the floating body, and, in this way, reduces the friction by the air cushions formed opposite a smooth surface of a body moved in the water...". The description of such vortices is an indication that the DE ('207) reference is suppressing turbulent drag by affecting/influencing the turbulent envelope. As with Meng, this is not particularly relevant to the present invention. That is, in contrast to the DE ('207) reference (and Meng), as discussed in the prior Amendment and further detailed hereinabove, Applicants' claimed invention is directed to "skin" drag reduction without concern with (or influence of) turbulent drag or turbulent envelope due to the reduction in the liquid-solid interface achieved by the application of Applicants' nanostructures (or microstructures) on the surface of the body moving through the fluid. That is, applying the principles of Applicants' claimed invention allows a reduction in the contact area of the body's surface which actually comes in contact with the fluid in which such body is immersed thereby achieving the desired friction control.

In further regard to the DE ('207) reference, the disclosed technique also details a floating body that requires that the fibers are laid down (i.e., flat) and with their free ends pointing in a direction opposite the direction to movement to reduce drag (see, e.g., the DE ('207) reference at the Abstract; and page 2 and page 3). Further, the DE ('207) reference discloses the application of a conductive coating to the floating body's surface such that application of an electrical charge brings about an ionization of the water surrounding the floating body so that the friction of the moving floating body is reduced in the water (see, e.g., the DE ('207) reference, page 4, first and second paragraphs discussing Figure 4 and Figure 5, respectively). This ionization effect and migration of the water surrounding the floating body does not teach or suggest the aspect of Applicants' claimed invention wherein friction control is a function of a variable degree of contact between the surface and the fluid resulting from an electrically-induced penetration of at least a portion of said fluid through the nanostructures or microstructures.

The JP ('413) reference discloses a method of decreasing fluid resistance by bonding a knit fabric upon which microstructures are erected to provide a contact surface which is in contact with the fluid for changing the structure of the viscous sub-layer such that large-scale eddy structures are controlled, consequently decreasing turbulent flow

frictional resistance (see, the JP ('413) reference at the Abstract; column 1, paragraph [0008]; and column 3, paragraph [0022]).

So, the combination of the DE ('207) reference and the JP ('413) reference as set forth by the Office Action (1) delivers whatever friction control through suppression of turbulent drag and affecting a turbulent envelope, and (2) in certain forms will require that the fibers are laid flat and with their free ends pointing in the opposite direction of the movement through the fluid, and (3) that a conductive coating may be applied to the surface the floating body's surface such that application of an electrical charge brings about an ionization of the water surrounding the floating body so that the friction of the moving floating body is reduced in the water.

Clearly, however, for the at least the reasons discuss above any combination of the DE ('207) reference with the JP ('413) reference, at a minimum, does not teach or suggest Applicants' claimed invention because Applicants' claimed invention requires that the claimed friction control between the surface and the fluid is controlled as a function of a surface energy of the nanostructures or microstructures and wherein the friction control is a function of a variable degree of contact between the surface and the fluid resulting from an electrically-induced penetration of at least a portion of said fluid through the nanostructures or microstructures.

Further, as is readily seen from Applicants' specification and the associated Figures described therein, Applicants' claimed nanostructures or microstructures are not laid flat as would be required by the cited DE ('207)/JP ('413) reference combination. Why? Because, if laid flat the combination of electrowetting principles and nanostructure/microstructure surfaces of the claimed invention will be ineffective.

In addition, the ionization effect achieved in the cited DE ('207)/JP ('413) reference combination between the conductive coating and surrounding water is unrelated to the electrowetting principles of the instant invention which are employed to cause the fluid to at least partially penetrate the nanostructures (or microstructures) on the surface of the body in order to selectively create greater friction in a desired location of the surface. Said another way, even assuming *arguendo* that the cited DE ('207)/JP ('413) reference combination is proper, one skilled in the art would not understand such combination to teach or suggest achieving friction control is a function of a variable

degree of contact between the surface and the fluid resulting from an electrically-induced penetration of at least a portion of said fluid through the nanostructures or microstructures, as claimed by Applicants.

Further, regarding the Office Action's assertion on page 5 (in rejecting Applicants' claim 5) that the cited DE ('207) reference by " a mere presence or absence of electric current on the fibers will cause a variable penetration of fluid through the microstructures...". Applicants find such a reading unsupported by such reference. To establish a proper *prima facie* case of obviousness, three basic criteria must be met: (1) there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art to modify the reference or to combine reference teachings; (2) there must be a reasonable expectation of success; and (3) the prior art reference (or references when combined) must teach or suggest all the claim limitations. (See, Manual of Patent Examining Procedure (MPEP), Eight Edition, August 2001, as revised May 2004, § 706.02(j)). The Applicants respectfully submit that the Office Action fails to make a *prima facie* case of obviousness with regard to any of Applicants' pending claims, as amended herein, for at least the reasons hereinbelow.

Further, with respect to Applicants' amended claims 5 and 11, these claims are directed to a further aspect of the invention wherein the fluid is caused to penetrate the pattern of nanostructures or microstructures at a select location on the surface such that the penetration of the fluid at the select location alters a direction or a speed of the vehicle in the fluid (see, e.g., Applicants' Specification, page 2, lines 20-22; and page 12, line 27 through page 13, line 8). The DE ('207)/JP ('413) combination does not teach or suggest this further aspect of Applicants' claimed invention. Further the JP ('413) reference is directed to affecting the turbulent envelope/turbulent flow (similar to the previously cited Meng reference as mentioned above) and not utilizing a pattern of nanostructures or microstructures at a select location on the surface such that the penetration of the fluid at the select location alters a direction or a speed of the vehicle in the fluid, as claimed by Applicants.

Therefore, Applicants respectfully submit that neither the DE ('207) reference or the JP ('413) reference, taken alone or in any combination, teach or suggest the notion

where fluid is caused to at least partially penetrate the nanostructures or microstructures on the surface of the body in order to selectively create greater friction in a desired location of the surface thereby creating drag that alters the speed or direction of a body itself as it is propelled through the fluid, as claimed by Applicants in pending claims 5 and 11 herein.

Further, regarding the rejection of each of the presently pending dependent claims these claims depend ultimately from one of the pending amended independent claims 1 or 6, as the case may be, which Applicants submit are patentably distinct over the DE ('207) reference and the JP ('413) reference for the aforesaid reasons. Thus, these dependent claims contain all the limitations of the pending amended independent claims from which they depend, and Applicants respectfully submit that these dependent claims are also patentably distinct over the DE ('207) reference and the JP ('413) reference for the aforesaid reasons, as well as other elements these claims add in combination to their base claim.

Allowable Subject Matter

The Office Action on page 6, Section 9 indicated that claims 3, 4, 8, and 9 would be allowable if (1) the rejection under 35 USC § 112, first paragraph, is overcome; and (2) the claims are rewritten to include all of the limitations of the base claim and any intervening claims. In view of the discussion above, Applicants submit that all of the currently pending claims 1-11, as amended herein, are patentable over the cited prior art and are currently in condition for allowance.

In view of the foregoing, Applicants respectfully submit that each of the currently pending claims, as amended, are patentably distinct over the DE ('207) reference and the JP ('413) reference, either taken alone or in any combination, therefore, Applicants respectfully submit that each of the currently pending claims in the application is in condition for allowance and reconsideration is requested. Favorable action is respectfully requested.

Should the Examiner believe anything further is desirable in order to place the application in even better condition for allowance, the Examiner is invited to contact the undersigned at the telephone number listed below.

Respectfully submitted,

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